or July weather the number of small creatures harbouring in such a position as, say, a patch of rank herbage near water is truly astonishing. During the last ten years I have often visited such positions in heavy rain, and I am convinced that great mortality is caused, but I have not been able to satisfy myself whether this is due to drowning, burial in the soil, the impact of falling drops, or to some other cause or combination of causes.

Over an area not subject to violent meteorological fluctuations, the fauna will assume a condition of equilibrium. Any sudden and wide departure from the mean conditions for the particular season of the year will have an immediate and profound effect. I venture to write, therefore, in the hope that someone will pay special attention to the effects of such periods of abnormal rainfall as we have had during the last few months. The subject does not appear to have received the attention it merits, and the inquiry might profitably be extended so as to cover other meteorological effects. W. RUSKIN BUTTERFIELD.

4 Stanhope Place, St. Leonards-on-Sea, January 17.

### Subjective Images.

THE letter on the above subject (p. 271) reminds me of one that I sent to NATURE in 1871 (vol. iv. p. 122) describing a phenomenon complementary to that observed by Mgr. Molloy. I was induced to write it in consequence of a communication by Mr. T. Ward (NATURE, vol. iv. p. 68), who observed that the white chalk lines on a blackboard appeared to be blue when the sun was shining on his eyes; I noticed that the printing in a book looked bright red when I was walking on a chalk road, the book being shaded by an umbrella.

There appears to be a connection between the three phenomena, but I will not venture to suggest an explanation; possibly the persistence of colours may be different in different eyes. HERBERT MCLEOD.

January 23.

IN response to Dr. Molloy's appeal, I may mention that a correspondent of *Work* having asked the reason for the colours in Benham's artificial spectrum top, I made, in the number for April 6, 1895, a suggestion which is practically the same as his explanation. This was that the optic nerves which according to the Young-Helmholtz theory produce the sensation of violet, are the most easily excited of the three sets, and that those producing the sensation of green, having the greatest inertia, are least easily excited and retain the impression for a longer time than the other two. In the number of the same journal for January 11, 1896, other phenomena were cited which might be explained by the same hypothesis. ALEX. THURBURN.

Keith.

IT seems probable that the effect mentioned by Dr. Gerald Molloy in your issue of January 21 is the same effect—produced in a different way—as that I spoke of in my letter published in NATURE of January 14.

In the instance he mentions we have black letters on a white marble slab, viewed by eyes in a partially dazzled state from the effect of strong sunlight. In the case to which I directed attention, these conditions are almost reproduced, viz. the blackened silver bromide on a white porcelain dish under a dazzling red light. Before the developing solution is added, the bromide under the red light appears as a grey powder in a white dish, but on adding the developing solution it is blackened, and when the liquid is poured off the change from black to bright green may be conveniently observed. The angle at which the dish is viewed seems not to be without influence on the brightness of the colour. Under the best conditions the bromide has the appearance of masses of uncut emeralds. T. A. VAUGHTON.

Ley Hill House, Sutton Coldfield, January 23.

### Abysmal Deposits.

I BELIEVE there is some difficulty in accounting for the difference in the distribution of living Foraminifera at the surface of the sea and of deposits of their skeletons at the bottom. As is well known, the abysmal deposits contain no Foraminifera, while the much vaster pelagic deposits consist chiefly of them. The difference in depth has suggested that in the case of the pelagic deposits the free carbonic acid in the water has not had time to dissolve the sinking skeleton, while it has had time before a skeleton can reach the greater depths occupied by the abysmal deposits. But surely if this were the whole truth some effect would have been produced by the time the skeleton had sunk 2000 or 2500 fathoms or even less, so that it ought to be impossible to find, as we do, perfect skeletons in the globigerina ooze.

I wish to suggest a theory which is new, so far as I know, viz. that solution does occur, but does not begin until the organic matter protecting the carbonate of lime has all putrefied away. Hence the solution may be begun and ended in the excess of depth which the abysmal parts of the ocean-bed have over the pelagic parts.

H. ROBSON.

29 Hurlbutt Street, Newington Butts, S.E.

### Spelling Reform.

IN your review of Dr. Joseph Bowden's "Elements of the Theory of Integers," there is included a severe condemnation of the very moderate instalment of spelling reform which the author appears to have introduced into his work. A discussion on the general question of spelling reform would, of course, not be suitable to your pages, and I therefore confine myself to making a respectful remonstrance against your reviewer's sweeping condemnation of what I conjecture to be an attempt to remedy a few of the glaring inconsistencies and anomalies of the current English spelling. Other languages have, from time to time, reformed their spelling so as to bring it more into harmony with the pronunciation, and this has been the case in our own time with German. It can scarcely be doubted that, sooner or later, the same will be the case with English. In that event the spellings you quote will certainly be adopted, with the exception of "*fixd*," which will, of course, be spelt *fixt*. T. B. S.

Edinburgh, January 15.

MAY I point out that Dr. Bowden's book purports to deal with the "Elements of the Theory of Integers," and not with questions of spelling reform? Neither on the title-page nor in the preface does the author make any claim to address his work to those members of the community who prefer to have their thoughts expressed in a written language differing from that of their fellow beings. Failing any such indication, it must be assumed that the work is intended to be read and criticised by English speaking and English writing readers of the present day, to whom the author's spelling of the words in question must appear to be grossly incorrect. I quite agree with T. B. S. that "a discussion of the general question of spelling reform," as exemplified by the modern German equivalent of *red*, would "not be suitable to your pages."

THE REVIEWER

## *RESEARCHES RELATING TO RADIUM.*

THE year just passed has witnessed a widespread interest among all classes of people in Mme. Curie's discovery of radium, and attention has been generally directed to the nature of the new property of matter which it exhibits to such a surprising degree. The far-reaching consequences of M. Becquerel's discovery of radio-activity for the element uranium on our ideas with regard to the relations between energy and matter, although they have been long recognised by those immediately connected with the development of the subject, are now universally admitted. The million-fold more powerful radium appeals to the practical as well as to the academic imagination, and the problems raised by the new property have been brought into universal prominence. Owing to the excellent work of Giesel in improving the methods of extracting the new element from its

ores, and to the enterprise of the Chinin-Fabrik, of Brunswick, many during the past year have had the opportunity of satisfying themselves by experiment that the marvellous properties attributed to radium have not been exaggerated.

Considering the short time that has elapsed since the discovery, and the difficulty experienced in the past in obtaining the element, our knowledge of its properties at the present time is surprisingly complete. Attention will here be mainly directed to outstanding features which need further inquiry. In the first place, in spite of the many years of painstaking labour devoted to the determination by Mme. Curie, doubt still lingers as to the atomic weight of the new element. The case is a remarkable one, and has never arisen before in the determination of an atomic weight. On the one hand we have Mme. Curie's experimental value 225, and on the other an indirect value, 257·8, arrived at by Runge and Precht from spectroscopic data. Each of these determinations rests upon evidence which cannot be lightly set aside, and the discrepancy still remains to be explained. We have the authority of M. Demarçay for the purity of the preparations employed by Mme. Curie, for the former states that the spectroscopic trace of barium present could have had no effect on the atomic weight determination.

In ordinary circumstances the value 225 would probably be accepted as trustworthy to a unit in either direction. Runge and Precht's result, on the other hand, cannot be ascribed to chance relationships between the lines in the spectrum, possessing no real physical significance. For they succeeded in sorting the lines into related series, the lines in each series being resolved in the same way in a magnetic field. The series for radium are strictly analogous to those previously recognised in the spectra of the other alkaline-earth elements, and the connection between the atomic weight of the element and the distance apart of the lines in the series, which is the same for the different series of the same elements, holds very exactly for the cases of magnesium, calcium, barium and strontium. For radium, however, the number 257·8 is indicated. The evidence drawn from the chemical nature of radium and from the character of its spectrum agrees, however, in making the new element a member of the alkaline-earth family, and the experimental number is the only one which admits of this classification in the periodic table. The higher value, if it allows of the element being placed in the group of divalent metals at all, would make radium analogous to mercury and cadmium, so that it seems as if the experimental number should be accepted and the spectroscopic value regarded as abnormal for some unknown reason. The question is of considerable importance, and it is to be hoped that new experimental determinations will soon be available.

An explanation of the property of radio-activity was put forward by Prof. Rutherford and the writer about a year and a half ago as a result of the discovery of thorium X and of the behaviour which the thorium from which it is separated exhibits. This has since been developed and extended to afford a working hypothesis applicable to every detail of the phenomenon. The radio-elements are regarded as slowly disintegrating, a definite proportion of the total changing in the case of each element in the unit of time, the change being marked by the expulsion of rays. On account of the fact that the disintegration proceeds *per saltum* through several stages, and once started proceeds from stage to stage comparatively rapidly, the infinitesimal amounts of the transition-forms of matter can be detected and studied on account of the rays they emit in passage to the next succeeding stage. On this view thorium X, the uranium X of Crookes, the emanations of radium and thorium, and the active matter resulting from the further change of the latter, which gives rise to the phenomenon of "induced" or "excited" activity, are all transition-forms in the *per saltum* disintegration of the parent elements into more stable systems. The emanations are perhaps the most remarkable of these forms, as they are gaseous, and in consequence have been the most narrowly studied since the original discovery of the thorium emanation by Rutherford in 1899. The energy given out is, on this view, derived from the store of internal energy of the changing atom, and is, for any given mass of matter changing, enormous compared with that involved in any previously known change. It is in consequence of this fact that the excessively minute changes which produce radio-activity can be detected and investigated.

With regard to the nature of the radiations, the advances made by Rutherford in our knowledge of the nature of the $\alpha$ rays are among the most important. The $\beta$ rays are known from the work of J. J. Thomson and Becquerel to consist of high velocity kathode rays, or negatively charged particles of mass about one-thousandth of the hydrogen atom projected with a velocity approaching that of light. The $\gamma$ rays are in all probability X rays of high penetrating power which accompany the production of the $\beta$ rays. Rutherford was the first to recognise that these two types are relatively unimportant, and that the $\alpha$ rays represent at least 99 per cent. of the total energy radiated. The analysis of the rays from a radio-element into its several parts, the greater part usually coming from the various transition-forms, which can be removed by chemical means, and only a small part from the parent element itself, has borne out this conclusion. For in the majority of cases known $\alpha$ rays are alone expelled in the disintegration. The discovery of the magnetic and electric deviability of the $\alpha$ ray of radium to an extent about one thousand times less, and in the direction opposite to that suffered by the $\beta$ ray in similar circumstances, enabled Rutherford to settle the question as to their nature by showing them to consist of projected particles carrying a positive charge, about one thousand times the mass of the kathode ray particle and therefore comparable in size to the hydrogen atom, travelling with a velocity about one-tenth that of light.

This discovery has two bearings. On the one hand it confirms in a remarkable manner the view of the nature of electricity adopted by J. J. Thomson as the result of his investigations of the conduction of electricity through gases, that the negative charge can be dissociated from the atom, whereas the positive charge is always associated with a particle of atomic dimensions. On the other, it provided at once a mental picture of the precise change suffered by the atom of a radio-element, which the discovery of thorium X and the investigation of its behaviour had established. To take the case of radium as an example. The $\alpha$ particle expelled is an integral part of the heavy radium atom, which after disintegration forms a new and lighter atom, viz. that of the emanation. This suffers a second disintegration, expelling more $\alpha$ particles and changing into the matter which causes the "excited activity." Owing to the average life of the emanation atom being short—only 5·79 days—its energy is liberated so rapidly that a correspondingly small quantity can be detected. The energy manifestations from the emanation are very surprising, although it is not present in sufficient quantity to be detected by ordinary means

An interesting feature at the present time arises from the fact that since the $\alpha$ rays given out by a

radium compound are derived from several distinct atoms, the parent radium atom, and the successive products of its disintegration, it is to be expected, as Rutherford has pointed out, that the velocity of the α particles will vary within certain limits. Becquerel, however, states that the α radium rays in his experiments were deflected as a homogeneous pencil. Moreover, according to the same authority, they possess the remarkable property of being the more difficult to deviate for any given strength of field the greater the distance of air traversed. Both these observations seem contrary to what we should expect, and the latter especially is difficult to account for.

With regard to the "spinthariscope" effect of the α ray when it impinges on a zinc-blende screen, discovered by Crookes, it appears probable from the work of Becquerel, Tommasina and others that the scintillations are not caused, as was at first thought, by the direct impact of the individual α particle, but are due to cleavages provoked in the crystals of the blende by the bombardment, each cleavage, rather than each impact, giving rise to a flash of light.

The spontaneous heat evolution of radium to the extent of 100 gram-calories per gram of radium per hour, which was established some months ago by Curie and Laborde by direct calorimetric experiments, although it is the fact about radium which has appealed most strongly to the general imagination, hardly came as a surprise to those who were aware of the other properties of the element. Rutherford and McClung in 1901 estimated the energy radiated from a gram of uranium oxide as at least 0·03 calorie per gram per year, and it was known that this must be increased at least a million times for the case of radium. In addition, the well known chemical actions of the radium rays—the conversion of oxygen into ozone, and the decomposition of water into its elements—showed that their energy must be very considerable. The recent discovery of Rutherford and Barnes that more than 70 per cent. of the energy evolved from radium is due to the insignificant amount of emanation and the products of its further change, less than 30 per cent. being due to the element itself, follows as a direct consequence of the disintegration theory. It furnishes, it would seem, an almost unanswerable argument against the view that the energy evolved from radium is derived from an external source of unknown nature.

The view that radio-activity proceeds independently of temperature, which was originally arrived at by Becquerel by his study of the radiations of uranium, and is now generally recognised, was confirmed by M. Curie last year by some careful measurements of the rate of decay of the penetrating radiation from a sealed glass tube containing the radium emanation. He showed that the rate of the decay was not affected by variations of temperature between 450° C. and −180° C. Since it is the universal experience, not only for variations in temperature, but also for all other agents, that the rate of disintegration is constant and unaffected by molecular forces, it follows that the causes at work which produce disintegration are at present entirely unknown. It appears certain that it cannot be brought about by any agencies with which we are familiar. Sir Oliver Lodge has suggested that the unstable condition results from the incessant radiation of the internal energy of the atom, the latter being a necessary consequence of the electronic theory of atomic structure.

The discovery by Sir William Ramsay and the writer that radium is continuously producing helium in sufficient quantities to be spectroscopically recognised marks a new phase in the development of radio-activity by bringing the problem within the range of the ordinary methods of chemical investigation. From the disintegration theory it followed that the accumulation, during past ages, of the final products of the change of the radio-elements must exist in the natural minerals in which these elements are found. The existence of helium in the radio-active minerals, and its absence from those which do not contain the radio-elements, coupled with the fact that this gas forms no compounds but exists in the minerals "occluded" in a curious and unexplained way, pointed strongly to the view that it had been formed as one of the products of the change of one of the radio-elements during past ages, and mechanically imprisoned within the mineral. This led to the experiments being undertaken. The gradual growth of the helium spectrum in a sealed tube in which the radium emanation was originally condensed by liquid air and all other gases removed by the pump, excludes the view that radium may form a slowly decomposing compound with helium. The amount produced, as theory requires, is excessively minute, and its detection with the small quantity of radium available was due to the extreme delicacy of its spectrum reaction, and to the refined methods of gas manipulation developed by Ramsay in his investigation of the rare gases of the atmosphere. The suggestion that has been made that the α particle is an atom of helium has not yet been experimentally proved.

These direct confirmations of the theoretical predictions show that our knowledge of radio-activity has passed from a purely descriptive basis. The numerous unrelated and inexplicable experimental facts which have accumulated during the seven years the property has been known have during the past year been co-ordinated harmoniously as the effect of a definite and consistent cause. Radio-activity, in consequence, claims to-day to rank as an independent science. It is a property which may be best described as added on. It manifests itself without affecting or being affected by the ordinary chemical and physical nature of the matter in question, and therefore belongs to the domain neither of physics nor of chemistry. There is in consequence reason for considerable satisfaction that the theory of atomic disintegration to which radio-activity has directly led is also in the nature of an addition to, rather than a controversion of, accepted scientific doctrines. Nothing could be further from the truth than the idea that it upsets in any way the atomic theory of chemistry. On the contrary, as the bearing of the conception comes to be more clearly seen, it will probably be recognised that it provides the atomic theory with a measure of confirmation and new evidence which advances it a little further in the direction of that direct experimental proof which we are so frequently being reminded it is impossible for any theory to attain.

FREDERICK SODDY.

## *OBSERVATIONS OF GLACIERS AND AVALANCHES.*[1]

BOTH the pamphlets mentioned below are issued by the Commission Française des Glaciers. The former mainly consists of a study of the glaciers about the head-waters of the Arc, a region which, forty years ago, had been visited only by a few Alpine climbers, who found the official maps far from accurate above the snow line; following this are notes about glaciers of the Grandes Rousses, a snowy ridge

[1] "Rapport sur les Observations Glaciaires en Haute-Maurienne, dans les Grandes-Rousses et l'Oisans, dans l'été de 1902." Par M. Paul Girardin. Revue de Glaciologie. No. 2. Année 1902. Par M. Charles Rabot. Pp. 121; illustrated. (Paris: Typographie Philippe Renouard, 1903.)

"Observations sur l'Enneigement et sur les Chutes d'Avalanches, exécutées par l'Administration des Forêts dans les Departements de la Savoie. Pp. 15. (Paris: Au siège du Club Alpin Français, 1903.